bacter, particularly in the presence of cellulose decomposing organisms.

The high acidity of the cranberry soils would preclude the very idea of finding the *Azobacter* in these soils and the early students[6] of this group of organisms were of the opinion that they can not live in acid media at all but the reaction has to be adjusted first to neutrality before the conditions are made favorable for their activities.

A Savannah bottom cranberry bog situated at Whitesbog, N. J., was used for this work. A part of the bog was limed three years ago and the crop was almost double of the corresponding plot, unlimed. Samples of the soil from the two plots were secured under sterile conditions and used for this study. The soil is nothing more than some white sand interwoven with decayed and living plant residues.

The hydrogen-ion concentration of the two soils was determined by means of the colorimetric method, using the phenol-sulfon-phthalein indicators suggested by Clark and Lubs.[7] The method corresponds very closely with the electrometric determinations using the hydrogen electrode, as was shown by Gillespie.[2] A definite amount of soil was shaken with double its weight of distilled water, then centrifuged; the supernatant clear liquid was syphoned off and used for the determination of the hydrogen-ion concentration. The unlimed soil had an hydrogen-ion concentration of pH = 5.4 to 5.6 while for the limed soil pH was 6.2—6.4.

The two soils were added in 10-gram quantities to 100 cc.c. portions of a sterile faintly alkaline nitrogen-free mannite solution and incubated at 25°. The solution in the flasks containing the limed soils became turbid in four days and a pellicle characteristic of *Azotobacter* began to develop in some flasks. On microscopic examination the solution was found to contain an abundance of *Azotobacter* cells and *Actinomyces* filaments. The solution in all the flasks to which the unlimed soil was added remained clear as in the control, but has shown a profuse gas production. On microscopic examination no *Azotobacter* cells and no *Actinomyces* filaments were discovered.

The limiting reaction for the existence of *Azotobacter* in the soil, expressed in the hydrogen-ion concentration is thus found to fall between pH—5.4 to 5.6 and pH—6.2 to 6.4 and is probably nearer the latter. This will confirm the results of Gainey[1] and Christensen[3] that an hydrogen-ion concentration of the soil = pH—6.0 is the limiting reaction for the activities of *Azotobacter* in the soil.

The occurrence of *Antinomyces* filaments together with *Azotobacter* cells suggests a still more interesting and important possibility, association between these two groups of soil microorganisms. As will be soon shown elsewhere many *Actinomyces* decompose organic residues very rapidly. The association between these two groups of organisms, change of reaction, and the action of *Actinomyces* upon the nitrogen-fixation by *Azotobacter* is being studied at present in this laboratory.

The importance of *Azotobacter* in cranberry soils, which can be effected by changing the reaction of those soils, thus becomes apparent: these organisms, whether alone or in association with others, utilize the plant residues as a source of energy and this allows them to fix the atmospheric nitrogen and increase its supply in the soil, which goes towards an increased crop production.

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[6] Lipman, *Ann. Rept. N. J. Agr. Exp. Sta.*, pp. 262–268, 1904.

[7] *Jour. Bact.*, Vol. 2, Nos. 1, 2, 3, 1917.

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